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THE
BOSTON
MACHINEIST.

—
FITZGERALD.

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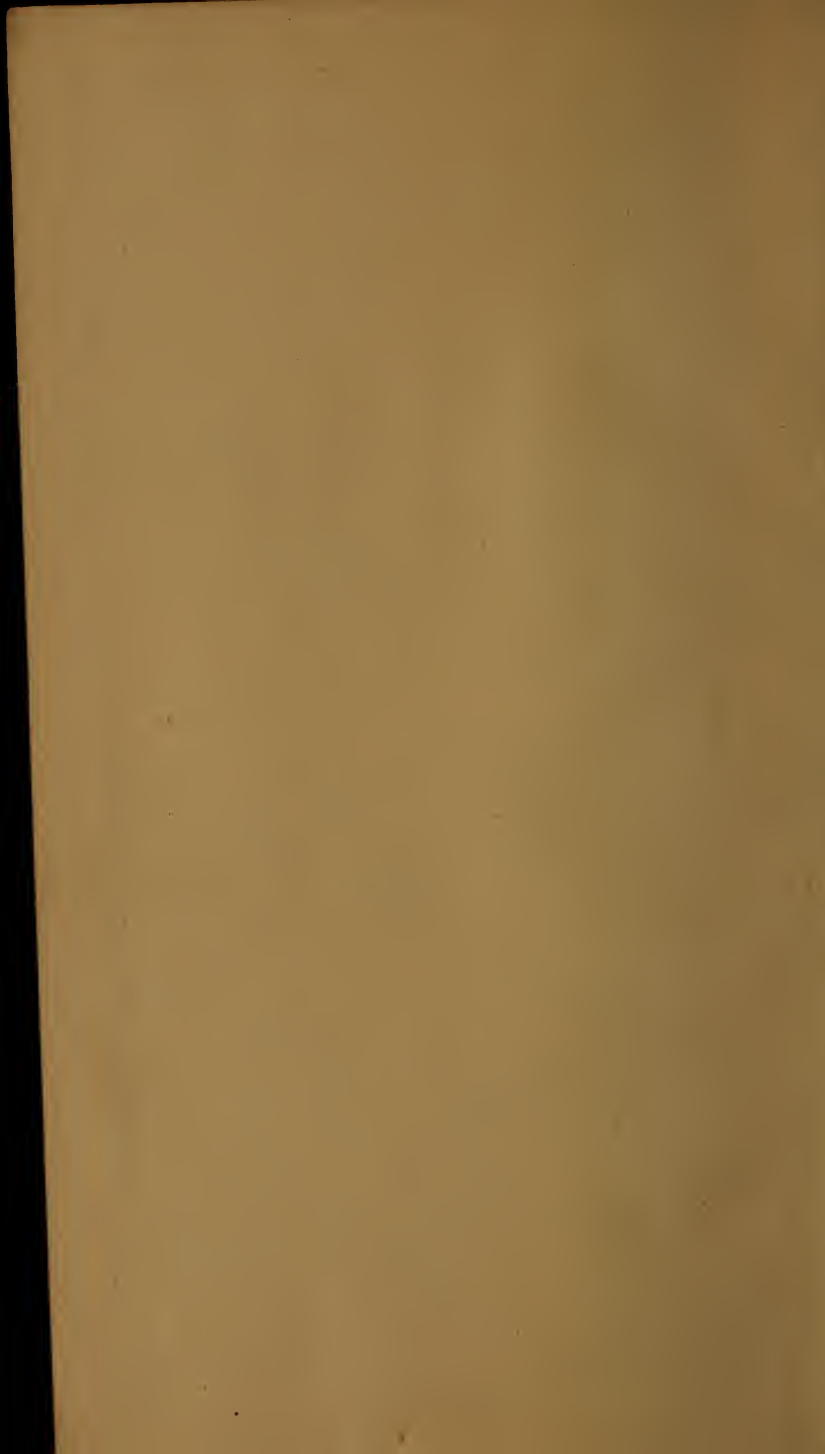
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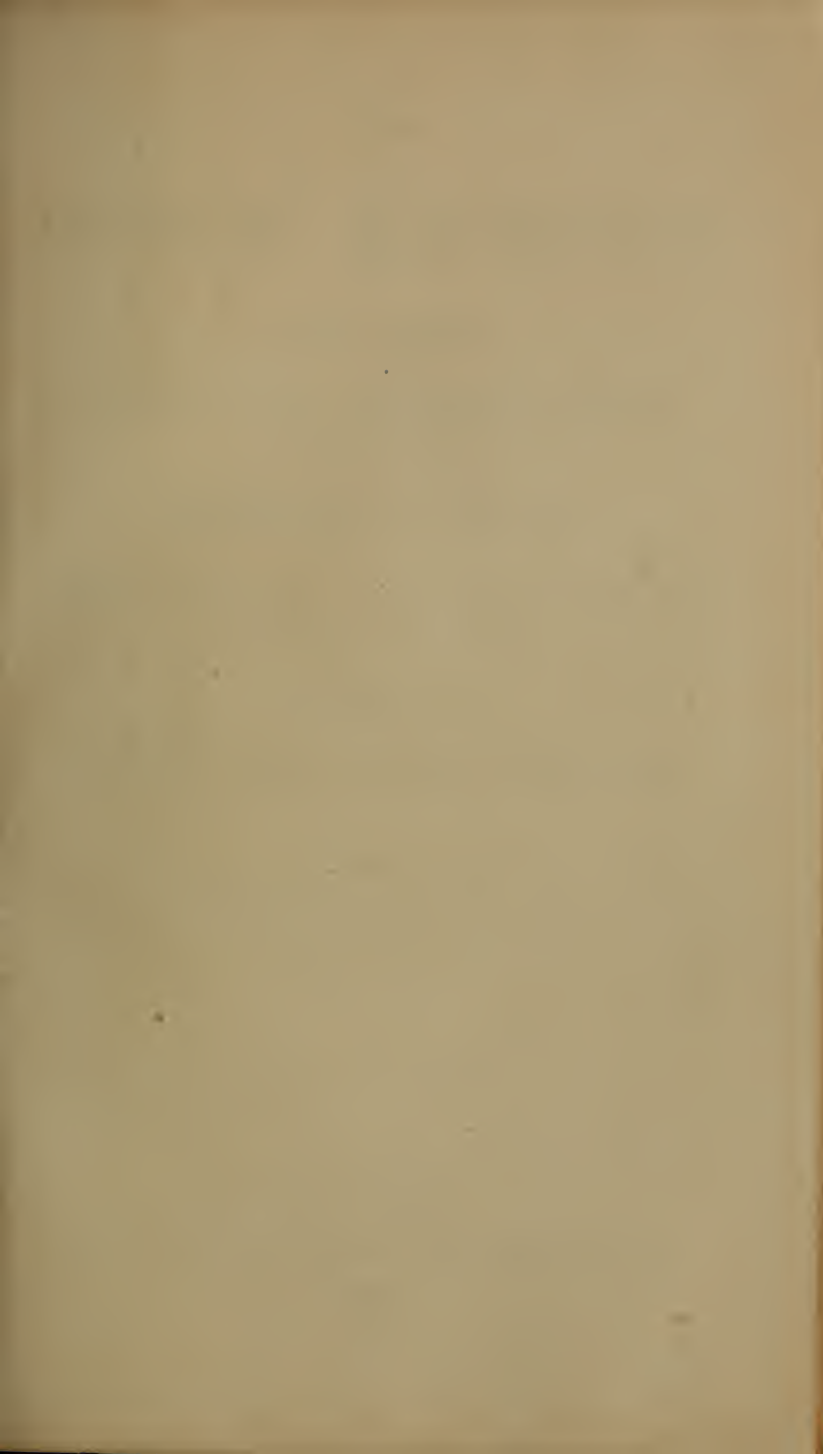
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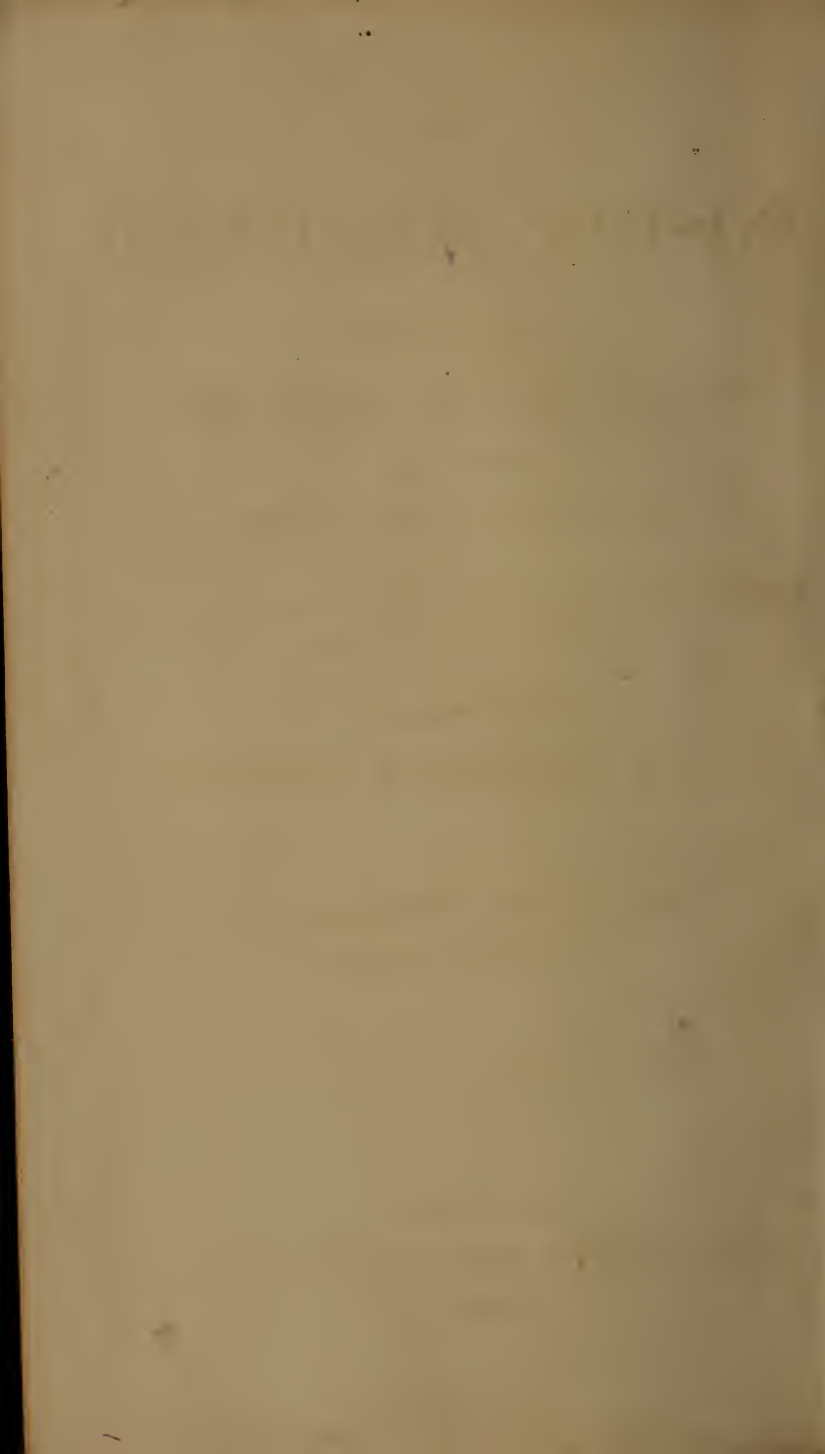
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THE
BOSTON MACHINIST.

BEING A COMPLETE
SCHOOL FOR THE APPRENTICE
AS WELL AS THE
ADVANCED MACHINIST.

SHOWING HOW TO MAKE AND USE EVERY TOOL IN EVERY
BRANCH OF THE BUSINESS.

WITH A TREATISE ON
SCREW AND GEAR CUTTING.

S
BY WALTER FITZGERALD,
Inventor and Mechanical Engineer.

NEW YORK:
JOHN WILEY & SON, 535 BROADWAY.
1866.

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CONTENTS.

	PAGE
1. The Apprentice's first lesson.....	9
2. Lesson second.....	9
3. Lesson third.....	11
4. Lesson fourth.....	11
5. Lesson fifth.....	12
6. To drill a large hole in the end of a shaft.....	13
7. Straightening Shafting.....	13
8. Setting a Lathe straight to turn Shafting.....	14
9. Turning Shafting.....	15
10. Setting a Lathe to turn Tapering.....	16
11. Tools for different kinds of Turning.....	18
12. Planer Tools.....	23
13. Chucking Pulleys.....	23
14. Setting the Chuck-rest.....	25
15. To drill a hole where you have no Reamer.....	25
16. Boring a hole with a boring tool.....	26
17. Squaring, or Facing up Cast Iron Surfaces.....	26
18. Scraping Cast Iron smooth.....	27
19. Keep your Lathe clean.....	27

	PAGE
20. Boring Holes and Boring Arbor.....	27
21. To make a Boring Arbor and Tool, that will not Chatter	28
22. Gearing a Lathe for Screw-cutting.....	29
23. Cutting a Screw in an Engine Lathe.....	30
24. Cutting Square Thread-Screws.....	31
25. Mongrel Threads.....	32
26. Planing Metals.....	33
27. Planing perpendicularly.....	33
28. Planing a Key-Way.....	33
29. Planing a T-shaped Slat.....	34
30. To Plane a Gibe-Rest or Slide.....	35
31. Note.....	35
32. Gear Cutting.....	36
33. Depth of Teeth.....	36
34. Measuring to find the Number of Teeth.....	37
35. Bevel Gears.....	38
36. The different Styles of Filing.....	39
37. To File a Square Hole.....	40
38. Draw-Filing and Finishing.....	40
39. Lining Boxes with Babbitt Metal	40
40. Making Lining Metal.....	41
41. Putting Machines together.....	41
42. Working Steel for Tools.....	42
43. Annealing Steel.....	43
44. Water Annealing.....	44

CONTENTS.

V

	PAGE
45. Hardening Steel Tools of the various Kinds.....	44
46. Dipping tools when hardening.....	46
47. Dipping a half-round file or reamer.....	46
48. Dipping a fluted reamer properly.....	47
49. Tempering tools	47
50. Fancy tool making.....	48
51. Making collets, or drill sockets.....	48
52. To make a collet properly.....	49
53. To make a collet for upright drills.....	50
54. Making drills.....	50
55. Spiral drills	50
56. Cutting the Spiral Grooves	53
57. Flat Drills for Chucking.....	54
58. Tap and Reamer Wrenches.....	55
59. Proportions for Tap and Reamer Wrenches.....	55
60. Tap and Reamer Wrenches, Size two.....	56
61. Tap and Reamer Wrenches, Size three.....	56
62. Wrenches for Taps and Reamers, Size four.....	56
63. Wrenches for Taps and Reamers, Size five.....	58
64. Wrenches for Taps and Reamers, Size six.....	58
65. Making Taps. The Turning.....	58
66. Proportions of Screws.....	59
67. Cutting the Threads.....	61
68. Square Thread-screws	63
69. Mongrel, or half V, half square Threads.....	63
70. Fluting Taps.....	64

	PAGE
71. How to go to work.....	64
72. Fluted Reamers	67
73. How to make a Fluted Reamer.....	67
74. Half-round Reamers.....	71
75. Rose Reamers.....	71
76. Counter-boring Tools.....	72
77. Making Dies for Screw-cutting	72
78. Milling Tools	73
79. Proportionate numbers of Teeth, in different Sizes...	74
80. Proportions of Broad Cutters.....	74
81. Punches and Dies.....	76
82. Making Gauges.....	77
83. Note on Balance-wheels.....	77
84. A few words as to Master Mechanics.....	78

PREFACE.

IN preparing this work, the author has endeavored to give to the Mechanic a volume that he can readily understand, though he may not have a full knowledge of the scientific terms commonly used in works of this kind. He has also aimed to give a full explanation of every subject treated of in as few words as possible. He had thought of adding an article on the proper speed of turning and planing metals; but as they vary so much in hardness, it is almost impossible to lay down any safe rule, and he has therefore concluded to omit it. He has also purposely omitted the subjects of Geometry and Machine Drawing, as they would have extended the volume beyond its proposed size; and, besides, there are already published many good treatises on these subjects. Asking, therefore, that due allowance may be made for all omissions and imperfections, he submits his little work to the hands of those for whom it is intended.

BOSTON, *Feb.* 27, 1866.

THE BOSTON MACHINIST.

1. *The Apprentice's first lesson.*

THE first thing for the Apprentice to learn is: to clean and keep in order, the lathes, planers, drills, milling and slabbing machines. This is done by brushing off the chips, and then wiping them with a wad of cotton waste. To clean a lathe, run the carriage and puppet-head about four feet from the main head, then to keep the feed and gears clean, brush all the chips towards the carriage, and after doing this, wipe the head and ways, clean and oil them. Then, after cleaning the carriage and puppet-head, run them back to the main head, brush the chips from the lower end of the lathe, wipe and oil the ways, and it is done.

2. *Lesson second.*

The next lesson is: to learn to trim castings. This is done by chipping off the rough

1.—Side view of a Fluted Reamer.



2.—A Mongrel Thread Screw for great wear.

places with a cold chisel and then filling them smooth with a second-hand file, which answers quite as well as a new one.

3. *Lesson third.*

The next thing to learn is, to centre bolts, shafts, etc. To do this, take a centre-punch and hammer, and punch it into the centre of each end of the shaft, or bolt as near the centre as you can guess; then find a pair of bench centres and spring them apart, putting the points into the punch-marks you have made in each end of the shaft. After doing this, take a piece of chalk in one hand and turn the shaft with the other, holding the chalk near enough to the shaft, near the ends, to touch the side that runs out. When you have done this take the shaft from the centres and remove the punch-mark towards the side marked by the chalk. Continue these operations till the shaft is true at the ends.

4. *Lesson fourth.*

Having learned to centre a shaft, you will now proceed and learn to drill the centres. In doing this, use a drill about one sixteenth of

an inch in diameter. Put the drill into a hand lathe, and with one end of the shaft upon the centre, drill the other, continually turning it around while drilling. They should be drilled about one fourth of an inch deep. After doing this, countersink them with a three-square countersink, made for the purpose.

5. *Lesson fifth.*

You will now learn other modes of drilling,—the first being to drill holes through flat pieces of iron. In doing this they are first laid out a certain distance from the edges with a pair of dividers. Then make a punch, mark the distance from the edge or position where you wish to drill the hole. After marking this punch-mark, set your dividers the size you want to drill the hole, and strike a circle around the mark made by the punch. Having done this, proceed to drill the hole, taking great care to drill within the circle, and if your drill runs to one side, chip a piece out of the opposite side with a half round chisel,—this will bring the drill back to the centre of the circle. Continue this practice till the hole is perfectly true, and if you are careful at the first

you will find no difficulty in drilling holes, and drilling them properly.

6. *To drill a large hole in the end of a Shaft.*

This is only done when you have no chuck that will hold the shaft. To do it properly, drill a small hole the depth required with a straight spiral drill; or if you have none use a flat one that is straight on the sides; then follow with one or two more larger sizes as may be required. The object of using a small drill first, is because being less pressure endwise on the drill it will not run out sidewise, as it would if the small holes were not drilled first. In drilling with small drills, such as centre drills, always speed up your drill as fast as it will run. This prevents the breaking drills, and there is no danger of burning the points off, as some suppose, except the steel be very hard.

7. *Straightening Shafting.*

This should be done by centring, as before explained; then put into a lathe, and the ends squared up with what is called a side-tool. After doing this, take a piece of chalk and try

it in several places, to find out where the worst crooks are; then, if you have not a machine for springing shafting, spring it with a lever where the worst crook is, and continue this operation till the shaft is straight.

8. *Setting a Lathe straight to turn Shafting.*

First, see if your centres are true; if not, turn them up. For this purpose a square-end tool is best; and they should always be kept true to a three-square gauge. Unless you do this, you will spoil about half your work, as many a one *has* done. After this is done, set your puppet-head so that it will turn the shaft straight; and if it has no straight mark upon it, turn one end of the shaft for about an inch; then, without moving your tools, take the shaft out of the lathe. Then run the carriage down to the main head, put your shaft into the lathe again, with the end which is turned towards the main head, and if the tool touches the place you have turned, the lathe is straight. If it does not touch, screw over the puppet-head, and keep trying it until your tool touches the place turned, at either end of the lathe.

9. *Turning Shafting.*

To do this properly, two chips should always be run over the shaft, for the reason that it saves filing and leaves the shaft truer and more round; and on shafts thus turned, the time saved in filing more than compensates for the time lost in turning. Before you commence, you will put your feed-belts or gear on a coarse feed. Turn off one a sixty-fourth of an inch larger than the size required. Having turned off this chip, commence the finishing-chip, and turn it small enough to have the pulley-wring on about an inch without filing. This will leave it large enough to file and finish. If there are couplings to go on a shaft, with holes smaller than the holes in the pulleys, the ends of the shaft, where they fit on, should be turned down to a sixty-fourth of an inch of the size desired before any part of the shaft is finished: that is, *every* part of a shaft should be turned to within a sixty-fourth of an inch of the size required, before *any* part of it has the finish-chip taken off. The reason for this is, that it leaves every part of the shaft perfectly true, which would not be the case

were it done otherwise. Having done this, you will file the shaft so that the pulleys will slide on, and the couplings so that they will drive on, polish the shaft with a pair of polishing-clamps and some emery, and it is done.

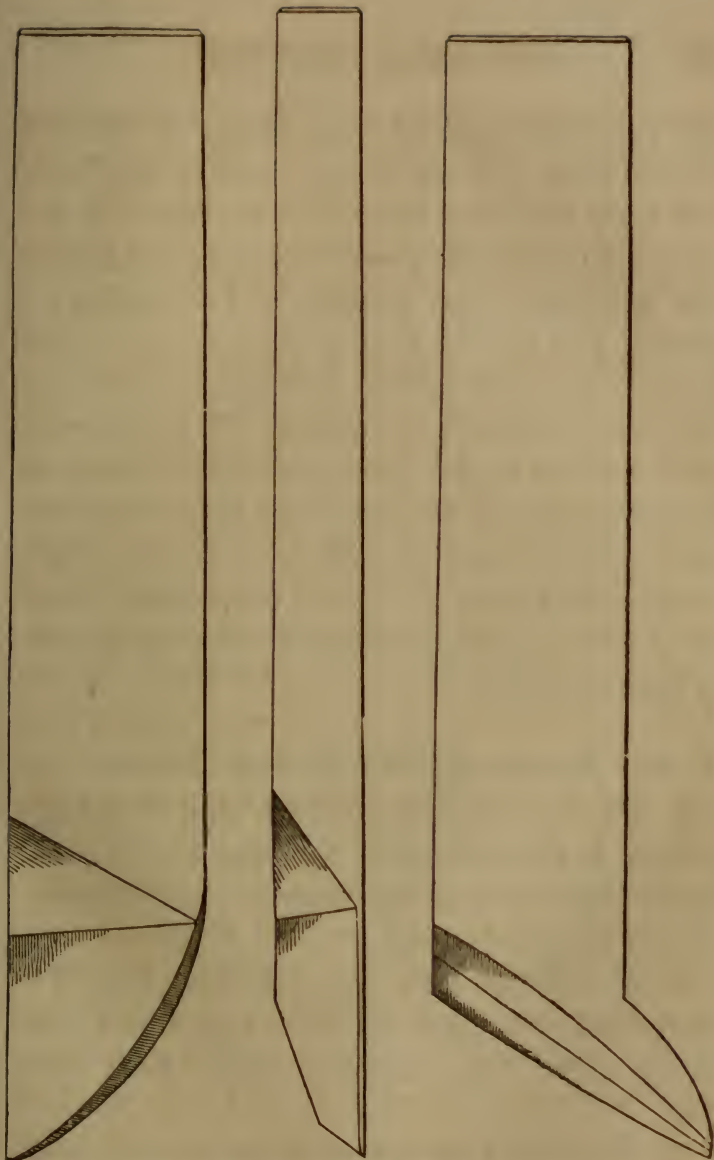
10. *Setting a Lathe to turn Tapering.*

This is done by calculating the taper, a certain amount to the foot or length of the piece to be turned. Therefore, if you have a shaft to turn a foot long, with one end one inch larger than the other, you will set your puppet-head over one-half inch, and you will get the required taper of one inch to the foot. If you have a shaft a foot long, and wish to turn one-half of it tapering half an inch, you will set the puppet-head over half an inch, as before; for the shafts being a foot long, you must calculate your taper from the length of the shaft: and if the taper is half an inch larger than six inches from the end, and the shaft exactly a foot long, the taper would be as before, one inch to the foot. If you have a shaft to turn that is twenty inches long, and you wish to turn it tapering two inches in its whole length, set your lathe over one inch, and this will give

3.

4.

5.



3.—A Right-hand Side Tool—side view.

4.—A Left-hand Side Tool—top view.

5.—A Round-ended Tool, for turning heavy shafting, facing cast-iron, etc.

you the taper required—two inches in twenty. If you have a shaft twenty inches long, and you wish to turn a taper half an inch in five, set your puppet-head over one inch, as before; this will give you a taper of five inches in twenty, and half an inch in five; because half an inch is one-fourth of two inches, and five inches is one-fourth of twenty. If you have a shaft twenty inches long, and want to turn it taper one inch in ten, set your lathe over one inch as before, and you have it; for the shaft being twenty inches long and two inches taper in its *whole* length, it would be one inch only in half its length.

II. *Tools for different kinds of Turning.*

1. The best tool for squaring up the end of a shaft is what is called by machinists a side-tool. The best tool for turning small shafting is a diamond-point tool.

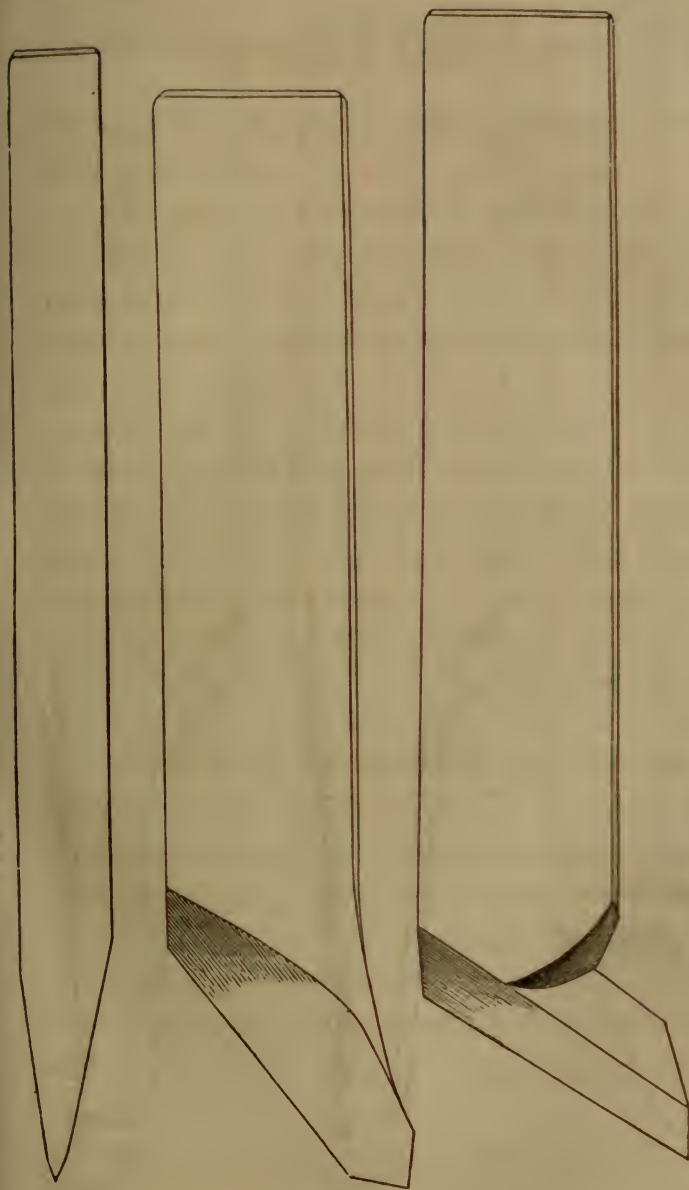
2. The best tool to turn heavy shafting is a round-end tool, made to stand high like a diamond point, and to cut freely from the side.

3. The best tool to turn a balance-wheel of cast-iron, or to square up any large surface, is

6.

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6.—Top view of a Screw-Tool, for cutting V threads.

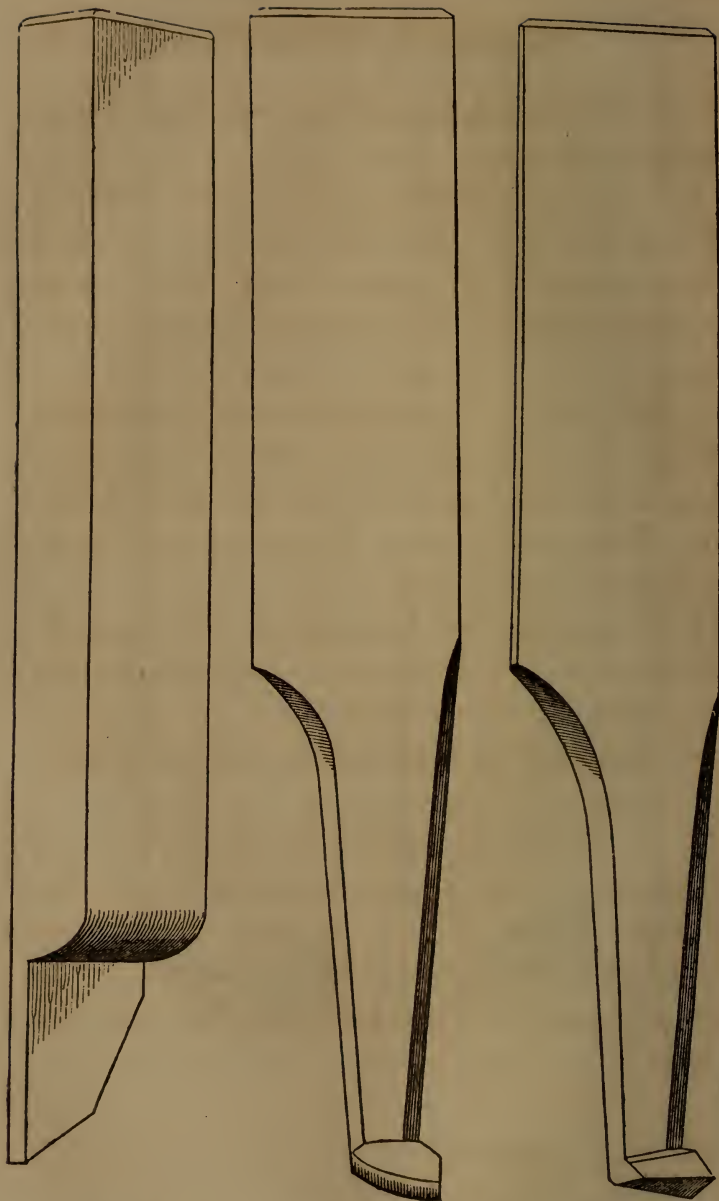
7.—Side view of a tool for cutting V threads.

8.—A diamond-point Tool, for turning small shafting.

9.

10.

11.



- 9.—A Tool for cutting off a shaft; is also used for cutting square thread-screws.
10.—A Lath-boring tool.
11.—A Tool for cutting a Screw inside a hole.

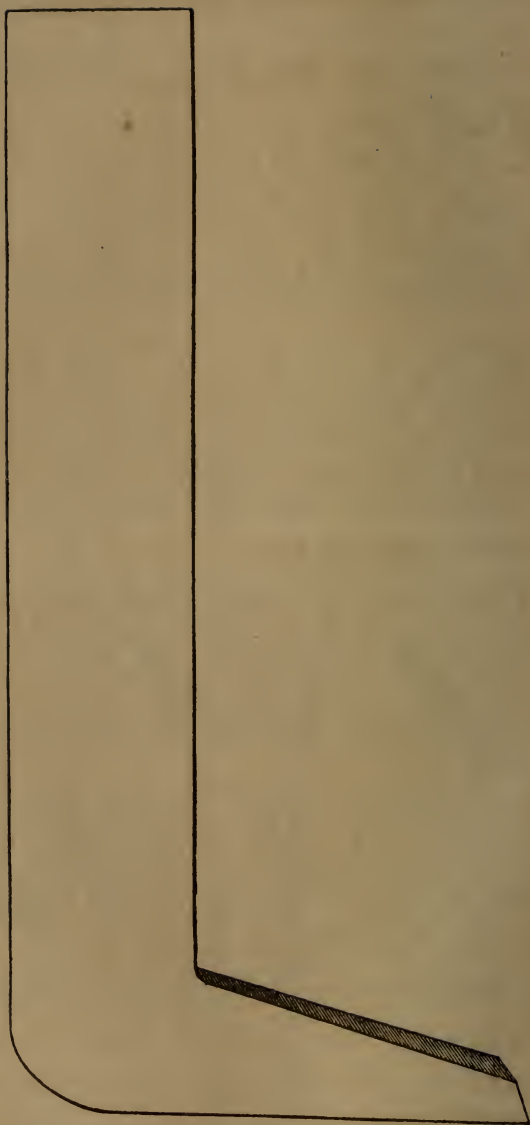
also a round end tool, made well tapering to cut from the side.

4. The best tool to cut off a shaft with is a tool made thin and having the tapering down, instead of up as in turning tools; this generally prevents their running in and breaking.

5. The best tool to bore out a hole is a lathe-boring tool with the end turned on a right angle to the left and the point turned up hooking. These tools bore far nicer than those made square on the top.

6. The best tool with which to cut a V thread-screw, is a V thread-tool with the points ground to lean down when finishing; as it prevents running and breaking the tool, or tearing the screw.

7. In cutting a square thread, first use a square-point tool about three-fourths of the thickness of the thread you design to cut, and finish with one the size of the thread. The same rule applies when cutting a thread within a hole.



12.—A Tool for planing a Key-Way.

12. *Planer Tools.*

The best tool for ordinary planing, is a half-side tool made short, and with the point turned up, as an ordinary diamond point.

The best tool for squaring up, is a round-point tool, cutting from the side.

The best tools for planing under, as in slide rests, etc., etc., are sharpened up to a point, with the point turned up, and with a taper from the point to the body of about two inches.

13. *Chucking Pulleys.*

The term chuck, means to secure a piece of work in a certain position, so as to drill, or plane it true. The same name is given to the instrument employed in holding the pieces of work. It is merely a round piece of iron, with a hole in one side of it, within which is cut a screw, for the purpose of securing it to the spindle of a lathe. On the side opposite, is a certain number of jaws, usually three or four, which screw together for the purpose of holding a wheel, or other piece of work, while it is being drilled. In chucking a wheel or pulley, the first thing to be done, is to screw it into the

jaws of the chuck, as near the position desired as you can guess. After doing this, screw a tool into the post, and set one end of it near the face of the pulley, then turn and adjust the wheel by means of the screws, until the tool touches it all round. After doing this, true the edges in the same way. And then, try the face again to see if it has moved. Some wheels are cast oblong, by the pattern's shrinking; and when wheels come this way, the proper mode of chucking them, is to set your tool against the face as before, turn and adjust the wheel so that it will touch the tool at two opposite points, then, with a rule, measure the two points farthest from the tool, and adjust them so they will be equal, and the wheel will be true. Some mechanics use a piece of chalk, but this is an improper way to true a wheel, even when it is perfectly round, for a wheel that is not chucked and drilled true, costs more time in turning than is needed to chuck and drill half a dozen wheels and pulleys, that are perfectly drilled, for patterns should be trued by the inside of the face and on the sides by the arms.

14. *Setting the Chuck-rest.*

In doing this, set it into the tool-post with the middles of the slats through which the drill passes, exactly as high as the centres of your lathe, for if it is above or below the centres, it will cut the hole larger than the drill, and thereby spoil the wheel. Having set the rest, you can proceed to drill the wheel. This should be done with two drills, and where the holes are cored badly out of true, even three should be used, if you would have the hole perfectly true, and the last drill should only cut a chip one-sixteenth of an inch. This leaves a good and true hole.

15. *To drill a hole where you have no Reamer.*

It is sometimes necessary to drill a hole of an exact size to fit a certain shaft, and at the same time have it smooth without reaming it. This may be done, by first drilling a hole, a one-hundredth of an inch smaller than the size desired, and then making a drill the exact size and running it through to finish with. This last drill should have the corners of its lips rounded, like a reamer, and the hole should be finished without holding the drill with a rest.

16. *Boring a hole with a boring tool.*

In boring a hole with a boring tool, it is usually necessary to drill the hole first, and too much care cannot be taken in finishing. An iron gauge should be made first; is usually made of a piece of sheet iron or wire. The hole should then be drilled smaller than the size desired, and then bored to the required size, and it is impossible to bore a hole perfect without taking two or three light chips, mere scrapings, with which to finish. Holes, in this way, may be bored as nicely as they can be reamed.

17. *Squaring, or Facing up Cast Iron Surfaces.*

A round-end tool is best for this. A rough chip should first be taken off, over the entire surface to be faced. Then speed your lathe up and taking a light chip, merely enough to take out the first tool-marks, run over the entire surface again. In turning up surfaces it is always best to begin at the centre and feed out, as the tool cuts freer and will wear twice as long.

18. *Scraping Cast Iron smooth.*

To scrape cast iron, it is necessary to put a rest close to the surface to be scraped, and then with a thin wide scraper, commence by resting your scraper on one edge and scraping, twisting the scraper, and sustaining it while cutting, in your hand. You must not bear on hard, but scrape as light a chip as possible, and you will have no trouble in scraping cast iron.

19. *Keep your Lathe clean.*

I again remind you of keeping your lathe clean, and your centres in shape, as, unless you do this, you will soon spoil every arbor in the shop; and the ways of your lathe will be torn away, so as to be unfit to have any nice piece of work done upon them.

20. *Boring Holes with Boring Arbor.*

A boring arbor is a shaft with a steel tool set in it, for the purpose of boring holes of great length, and is designed to be used in a lathe. In doing this properly, you must first see if your lathe is set straight. If not, adjust it;

having done this, put the piece of work to be bored in the carriage of your lathe, pass your arbor through the hole to be bored, and put it on the centres of your lathe. Having done this, adjust your work true to the position desired, by measuring from the point of the tool, continually turning round the arbor from side to side of the piece to be bored, while you are bolting it to the carriage, and measure until it is perfectly true. Having done this, bore the hole, and take for the last chip only a hundredth of an inch. This makes a true and smooth hole. It is impossible to make a hole true with any kind of a tool when you are cutting a large chip, for the tool springs so that no dependence can be placed upon it.

21. *To make a Boring Arbor and Tool, that will not Chatter.*

Boring tools, when used in small arbors, are always liable to chatter and make a rough hole. To prevent this, the tool should be turned in a lathe, while in its position in the arbor, upon the circle of the size of the hole to be bored, and the bearing lengthwise of the arbor, should be only as wide as the feed of the

lathe; for if the bearing of the tool is on the face, the more it will chatter.

22. *Gearing a Lathe for Screw-cutting.*

Every screw-cutting lathe contains a long screw called the lead screw, which feeds the carriage of the lathe. While cutting screws, upon the end of this screw is placed a gear, to which is transmitted motion from another gear, placed on the end of the spindle. These gears each contain a different number of teeth, for the purpose of cutting different threads, and the threads are cut a certain number to the inch, varying from one to fifty. Therefore to find the proper gears to cut a certain number of threads to the inch, you will first:—multiply the number of threads you desire to cut to the inch, by any small number, four for instance, and this will give you the proper gear to put on the lead screw. Then with the same number, four, multiply the number of threads to the inch in the lead screw, and this will give you the proper gear to put on the spindle. For example, if you want to cut twelve to the inch, multiply twelve by four, and it will give you forty-eight. Put this gear on the lead-

screw, then, with the same number, four, multiply the number of threads to the inch in the lead-screw. If it is five, for instance, it will give you twenty. Put this on the spindle, and your lathe is geared. If the lead-screw is four, five, six, seven, or eight, the same rule holds good. Always multiply the number of threads to be cut, first. Some, indeed most small lathes, are now made with a stud geared into the spindle, which stud only runs half as fast as the spindle, and in finding the gears for these lathes, you will first multiply the number of threads to be cut, as before, and then multiply the number of threads on the lead-screw, as double the number it is. For instance: if you want to cut ten to the inch, multiply by four, and you get forty. Put this on the lead-screw, then, if your lead-screw is five to the inch, you will call it ten, and multiply by four, and it will give you forty. Again put this on your stud, and your lathe is geared ready to commence cutting.

23. *Cutting a Screw in an Engine Lathe.*

In cutting V thread-screw, it is only necessary for you to practise operating the shipper,

and slide-screw handle of your lathe, before cutting. After having done this, until you get the motions, you may set the point of the tool as high as the centre, and if you keep the tool sharp, you will find no difficulty in cutting screws. You must, however, cut very light chips, mere scrapings, in finishing, and must take it out of the lathe often, and look at it from both sides, very carefully, to see that the threads do not lean, like fish-scales. After cutting, polish with an emery stick, and some emery.

24. *Cutting Square Thread-Screws.*

In cutting square thread-screws, it is always necessary to get the depth required, with a tool somewhat thinner than one-half the pitch of the thread. After doing this, make another tool exactly one-half the pitch of the thread, and use it to finish with, cutting a light chip on each side of the groove. After doing this, polish with a pine stick, and some emery. Square threads, for strength, should be cut one-half the depth of their pitch, while square threads, for wear, may, and should be cut, three-fourths the depth of their pitch.

25. *Mongrel Threads.*

Mongrel, or half-V, half-square threads, are usually made for great wear, and should be cut the depth of their pitch, and for extraordinary wear, they may even be cut one and a half the depth of their pitch. The point and bottom of the grooves should be in width one-fourth the depth of their pitch. What is meant here by the *point* of the thread, is the outside surface. And the bottom of the groove is the groove between the threads. In cutting these threads it is necessary to use a tool about the shape of the thread, and in thickness about one-fifth, less than the thread is when finished. As it is impossible to cut the whole surface at once, you will cut in depth about one-sixteenth at a time, then a chip off the sides of the thread, and continue in this way, alternately, till you have arrived at the depth required. Make a gauge of the size required between the threads, and finish by scraping with water. It is usually best to leave such screws as these a little large until after they are cut, and then turn off a light chip, to size them. This leaves them true and nice.

26. *Planing Metals.*

The first operation in planing, is to oil your planer and find out if the bed is smooth. If it is not, file off the rough places. Then change the dogs to see if they work well, and find out the movements of the planer. After doing this, bolt your work on to the bed, and if it is a long thin piece, plane off a chip, then turn it over and finish the other side, taking two chips, the last of which should be very light. Great care should be taken, in bolting it to the bed, not to spring it. After finishing this side turn it to the other side, and take off a light cut to finish it.

27. *Planing perpendicularly.*

In planing perpendicularly, it is necessary to swivel the bottom of the small head around, so it will stand about three-fourths of an inch inside of square, towards the piece you are to plane. This prevents breaking the tool when the bed runs back.

28. *Planing a Key-Way.*

To place a key-way in a shaft, it is necessary to first drill a hole, the size you intend to

make the key-way, as deep as you want to plane. Then with a square point tool, plane the key-way a little narrower than you design to finish it down to the proper depth. After doing this, finish with a tool of the desired size. Some think it unnecessary to use two tools to plane a key-way, and argue that it takes more time. This may be the case, but it is impossible to plane a key-way with one tool, especially a narrow one, without tearing it, and again it is impossible to tell whether or not the tool will run under sidewise until you have planed the way its depth. Therefore if you first plane the way with a narrow tool, and it is found to run under, it is very easy to set it right in cutting out the finish chip. In setting a tool to cut a key-way, set a square on the planer-bed, and try both sides of it near the point, to see that it is perpendicular. This will usually prevent its running under.

29. *Planing a T-shaped Slat.*

In planing a T-shaped slat, or way, such as are used for slides, or on a planer bed, to hold the head of a bolt, it is first necessary to plane to the desired depth, with a square point tool,

and after doing this, plane the upper part of the way to the desired width. Having done this, plane the bottom part of the way with two tools, one bent on a right angle, and the other to the left. And in planing large ways these tools should be made as small as they will stand without breaking, and should cut freely on each of the three sides. Make a sheet iron gauge, and plane the way to it. In small shallow ways they may be planed the depth and upper width at once, and then finished with one tool, made the desired shape of the way. This saves time.

30. *To Plane a Gibe-Rest or Slide.*

Plane it all over except the slide, first on both sides, then setting the planer head on an angle of thirty degrees, finish the slide with a taper point tool.

31. *Note.*

In planing metals, especially thin cast iron surfaces, it is always necessary to plane over a cut on both sides, before finishing, either for the outside or scales. Being harder than the inside, the moment the scale is taken off the

piece springs through the expansion of the scale on the opposite side. Hence the necessity of planing both sides before finishing either.

32. *Gear Cutting.*

In cutting gears, they are reckoned a certain number of teeth to the inch, measuring across the diameter to a certain line which is marked on the face or sides of the gear with a tool. This line is one half the depth of the teeth from the outer diameter. That is, if the teeth of the gear are two-tenths of an inch deep, this line would be one-tenth of an inch from the edge, and is called the pitch line.

33. *Depth of Teeth.*

Every gear cut with a different number of teeth to the inch, should be cut of a depth to the pitch line, to correspond with the number of teeth to the inch. This is called proportion. Therefore, if you cut a gear eight to the inch, the depth to the pitch line should be one-eighth of an inch, and the whole depth of the tooth would be two-eighths. Again, if you cut a gear twelve to the inch, the depth to pitch line

should be one-twelfth of an inch, and the whole depth of tooth two-twelfths. And again, if you cut a gear twenty to the inch, the depth to pitch line should be one-twentieth of an inch, while the whole depth should be two-twentieths, and so on, *ad infinitum*.

34. *Measuring to find the Number of Teeth.*

To find the size a certain gear should be, for a certain number of teeth, is an easy matter if you study carefully these rules. If you want a gear with thirty-two teeth and eight to the inch, it should be four inches, measuring across the diameter to the pitch line, and the two-eighths outside of the pitch line would make it four inches and two-eighths. Again, if you want a gear with forty teeth, and ten to the inch, it should measure across the diameter to pitch line four inches, and the two-tenths outside the pitch line would make the whole diameter four inches and two-tenths. And again, if you want a gear with eighty teeth, and twenty to the inch, it should measure to the pitch line, across the diameter, four inches, and the two-twentieths outside the pitch line would make it four inches and two-twentieths, and

these examples will form a rule for the measurement of all except bevel gears.

35. *Bevel Gears.*

These are turned a certain bevel to correspond with each other, according to the angle upon which the shafts driven by them are set. For instance, if two shafts are set upon an angle of ninety degrees, the surfaces of the faces of these gears will stand at an angle of forty-five degrees. To get the surface of these gears, in turning them, puts a straight edge across the face. Then set your level on an angle of forty-five degrees, and try the face of the teeth by placing the level on the straight edge. After turning the face of the teeth, square the outer diameter by the face of the teeth; and to get the size to which you wish to cut, measure from the centre of the face of the teeth. Thus, if a bevel gear is six inches in diameter, and the face of the teeth is one inch, you will measure from the centre of the face, and find it is five inches. On this line you calculate the number of teeth to the inch, and if you want a gear with twenty teeth, and ten to the inch, it should measure two inches across the face to the centre

of the surface of the teeth; and if the face of the teeth were one inch in length, the diameter of the gear would be three inches, and the inside of the teeth would measure only one inch. Again, if you want to cut a gear with forty teeth, and ten to the inch, it would measure four inches to the centre of the teeth on the surface. And if the surface of the teeth were one inch long, the diameter of the gear would be five inches, while it would only measure three inches inside the teeth. These examples will form a rule for all bevel gears.

36. *The different Styles of Filing.*

To file a surface true, it is necessary on commencing, to squeeze the file tightly between your third and fourth fingers and the palm of your hands, until you become used to it. Your position in filing should be half left-face to your work, with the middle of your right foot fifteen inches behind your left heel; and to file your work true or square, it is necessary to reverse your work often, as by this means you are enabled to see the whole surface you are filing, and to see, while filing, whether you are filing true or not. Where, however, your

work is so heavy that you cannot reverse it, you had better file first to the right, and then to the left, as by this means you can plainly see the file marks, and this again assists you in filing true.

37. *To File a Square Hole.*

To file a hole square, it is necessary to reverse the work very often. A square file should first be used, and the holes finished with either a diamond-shaped file, or a half-round one. This leaves the corners square, as they properly should be.

38. *Draw-Filing and Finishing.*

To draw-file a piece of work smoothly and quickly, it is best to first draw-file it with a medium fine file, and finish with a superfine file. After doing this, polish the work with dry emery paper, and then with emery paper and oil.

39. *Lining Boxes with Babbitt Metal.*

To line boxes properly, so as to insure their filling every time, it is necessary to heat the box nearly red hot, or at least hot enough to

melt the metal. Then smoke the shaft where the metal is to be poured upon it. This insures its coming out of the box easily, after it is cold. After smoking the shaft, put it into the box or boxes, and draw some putty around the ends of them, for the purpose of stopping them, taking care not to press upon it, for if you do it will go into the box, and fill a place that ought to be filled with metal; and in the meantime your metal ought to be heated, and after you have poured it, let the box stand till it is nearly cold; drive out your shaft, and it is done.

40. *Making Lining Metal.*

Melt in a crucible, one and a half pounds of copper, and while the copper is melting, melt in a ladle twenty-five pounds of tin, and three of antimony, nearly red hot. Pour the two together, and stir until nearly cool. This makes the finest kinds of lining metal.

41. *Putting Machines together.*

In putting machines together, no part should be finished except where it is necessary to make a fit, as it is sometimes the case that machinery

is miscalculated, and by finishing, it would be spoiled, while if it were not, it might be saved by slight alterations in design. And again, in finishing certain parts before you get a machine together, you are unknowingly finishing parts not necessary to be finished, and making them of a shape anything but desirable. This rule, however, is not intended to apply to machinery being made to detail drawings.

42. *Working Steel for Tools.*

In working steel for tools, great care should be taken to hammer all sides alike, for if one side is hammered more than another, it will cause it to spring in hardening. Again, steel, when being hammered, should be heated as hot as it will stand, until finishing, and should then be hammered until almost black hot, for the reason that it sets the grain of the steel finer, and gives the tool a better edge. The reason for heating the steel so hot while hammering, is simply because it makes the steel tougher when hardened, and softer when annealed; while if it were worked at a low red heat, the continued percussive shocks of the hammer would so harden it as to make it almost impossible to anneal

it, and at the same time render it brittle when hardened.

43. *Annealing Steel.*

In annealing steel, it should be heated as slowly as possible to a red heat, but never hot enough to scale, and should then have two days or more "to cool in." A piece of steel that is heated hot enough to scale, can never be annealed well, without working over, and is always rendered glassy, and bad to work. To prove this, take a steel shaft and heat it in several places, hot enough to scale, and in several others to a low red heat. Allow it to cool, and when you turn it, you will see at once that the places heated hot enough to scale, are considerably harder than those heated properly. All tools that are required to be hardened without springing, as cutters and reamers, should be turned to exactly one-fourth of an inch of their size, and then annealed before finishing. This takes the strains out, so that when they are heated for the purpose of hardening, they will not spring.

44. *Water Annealing.*

Heat the steel to a red heat, and let it lie a few minutes, until nearly black hot, then throw it into soap-suds. Steel, in this way, may be annealed softer than by putting it in the ashes on the forge.

45. *Hardening Steel Tools of the various Kinds.*

All steel tools should be hardened at a low red heat, or the lowest heat at which they will harden, and the larger a piece of steel is, the greater the heat required to harden it. This is on account of its taking longer to cool, for the moment a large body of heated steel is plunged into the water, the steam arising from the surface of the steel blows the water away from it, and thereby causes it to take more time in cooling. For instance, an anvil heated red-hot and thrown into a hogshead of water, would, instead of hardening, blow the water away from it and cool slowly, until the water boiled, and when taken out, would be as soft as before it was put in. Hence the necessity of hardening anvils under a jet of water, or a waterfall. Very small tools, as needles and centre-drills,

penknives and lancet-blades, should be hardened in oil, or in water slightly warmed, as by cooling in cold water, they cool too quickly, and are either rendered brittle, or cracked, so as to be worthless. This is also the case in hardening springs—they are almost invariably broken, when hardened in cold water, and therefore should be hardened in oil. I have a razor which, being too soft, I hardened in oil—after being concaved—without springing in the least, and it is now as good a razor as I ever used. A piece of steel for a tool of any kind should never be heated hot enough to raise scales on it, except where it is so large that it will not harden without; for steel, when hardened at that heat, is rendered coarse in grain, and brittle, and you may draw the temper of it to a straw color, and it will still break more easily than a piece hardened at a low red heat, and not drawn at all, and at the same time the piece that is heated hot enough to scale, and drawn, will be softer than the piece hardened properly. Hence it is necessary to take great care, in hardening steel for tools.

46. *Dipping tools when hardening.*

To harden a penknife blade, lancet, razor, chisel, gouge-bit, plane, spoke-shave, iron-shaving knife, three and four-square files, and round and flat files, dip them endwise or perpendicularly. This keeps them straight, which would not be the case were they dipped, or put into the water otherwise.

47. *Dipping a half-round file or reamer.*

To dip a half-round file, or any tool that is solid, half-round, dip it with the half-round side twenty degrees leaning towards the water. This hardens it nearly straight. It is necessary here to remark that the surface of any piece of steel that is half round, has half as much again surface on the half round side to be hardened, as the flat side has, and the contraction of the steel being equal, according to the surface, the necessity of dipping the half-round side at an angle, is apparent. That is a half-round surface tending to one point, which is, or has one and a half, the surface or power of contraction, as the flat side. This contraction is what draws a piece of steel to one side, and makes it crooked.

48. *Dipping a fluted reamer properly.*

Dip it perpendicularly to a short distance beyond the fluting—that is to say, about half an inch, and withdraw and return it several times. This hardens all the lips, and prevents its cracking off at the water's edge, which is the case when a piece of steel is dipped in to a certain depth, and allowed to cool without moving. Arbors or mandrels are often broken off at the ends in this way, without the workman's knowing what caused them to crack.

49. *Tempering tools.*

Drawing the temper of tools, is usually done in a charcoal flame, and to draw the temper of a tool properly, it should be held in the thickest part, or the part not requiring any temper, towards the fire, and in the meantime, should be often wiped with a piece of waste or a rag, dipped in oil. The oil keeps the temper even, and prevents its drawing more in one place than another. And in drawing the temper of any tool it should be drawn very slowly,—otherwise it will run too far ere you are aware of it. Lancet-blades and razors should be drawn to a straw color. Knife-blades and

chisels should be drawn to a copper or almost red color. Plane irons, shaving knives, and shoemakers' knives the same temper. Cold chisels and stone drills should be drawn to a dark blue. Fluted reamers should only be drawn to a straw color, on the end, as they never break elsewhere, and keep their size longer by leaving the lips hard. Half round or tapering reamers, also taps, dies, and drills, should be drawn to a straw color. Jijucs and gauges, also common lathe tools, need no drawing, being tempered enough when merely hardened.

50. *Fancy tool making.*

Probably no profession among the fine arts is more "scientific," or requires greater care, than the art of gun, and watch, or fancy tool making, and it is safe to say, that not one machinist in five hundred will make a *good* tool maker. We will now commence on—

51. *Making collets, or drill sockets.*

The best collets for drill lathes are those which screw on to the spindle, and provided with a tapering hole, for the shank of the drill and a key-way, to hold the end of the drill

from turning. These collets are always true, and you have not the trouble trueing your drill whenever you use it, as with others. Collets for ordinary job shape, should be made with a set screw to hold the drills, and the hole for the drill shank should be drilled to fit round drill steel, about seven-sixteenths of an inch in diameter. This saves fitting the shanks of drills, and these drills are quite as good as drills made of forged steel.

52. To make a collet properly.

For such collets as screw on to the drill lathes bore out the end and cut the screw to fit the spindle well, and when you have done this, screw it on the lathe where it is to be used. After doing this, drill a hole for the drill-shank about an inch and a quarter deep, taking care to drill it perfectly true, then ream its tapering. Having done this, cut a key-way through the solid metal, below the bottom of, and running into the hole drilled for the shank. This key-way should be half an inch long, and a fourth wide. It is intended to hold the drill, the end of which is filed flat.

53. *To make a collet for upright drills.*

Drill the centres, and turn up the end to be drilled for the shank, so it will run in a back rest, and after doing this, put the end to be drilled into the back rest and the other end on the centre of your lathe, and drill the hole for the shank. When you have done this, take it out of the back rest, and using the hole for a centre, turn it to fit the drill, put a set screw in it, and it is done.

54. *Making drills.*

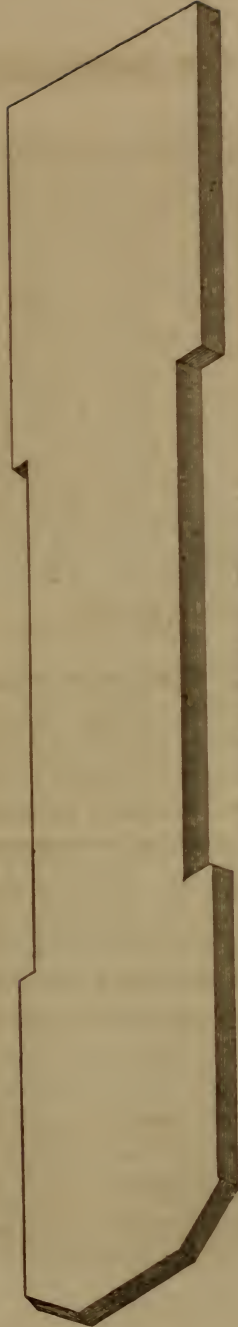
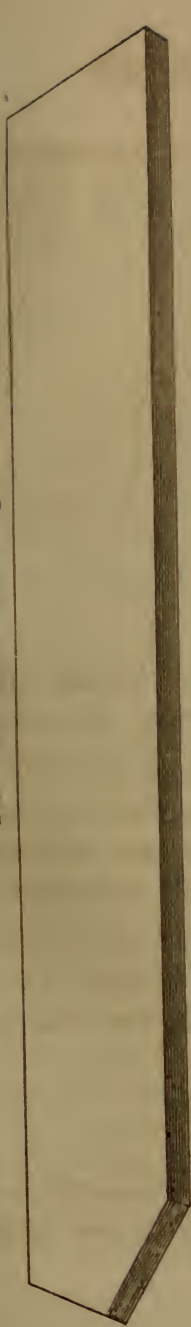
There are numerous styles of drills. Every drill should be made straight on the sides of the lips, for at least half an inch from the end. This prevents their running under or to one side. To this rule, however, we will except very small drills, as they would, if made in this way, soon get broken by the small particles of iron dust that force their way between the sides of the drill, and the sides of the hole being drilled.

55. *Spiral drills.*

To make a spiral drill, anneal it and turn it one-fiftieth of an inch larger than you intend it



14.—Flat Drill for Chucking.



15.—Flat Drill for Chucking.



16.—A Tap or Reamer Wrench.

to be, when finished. Then heat it again, and anneal it in a perpendicular position, either by putting it into lime or ashes in an upright position, or dipping it into soap-suds. After doing this, turn the shank to fit a certain collet socket or chuck (the names are various in different shops), and after doing this, you may turn the point or end to the desired shape and size. Then measuring from that point, turn it tapering, one-hundredth of an inch smaller, for every two inches of the drill's length, and the turning part is done.*

* The reason for again heating a piece of steel after partially turning it, is simply because it is often hammered harder on one side than the other, and the turning it true, frequently takes more stock on one side than the side opposite. This leaves the side from which the lightest chip is taken much harder than the other, and this is the principal cause of a reamer or other slender tool's springing when it is hardened. Again, annealing tools in a perpendicular position is better than to lay them on their sides, for the reason that they sometimes lie with their weight at each end, and this will always spring a reamer, or other slender tool. Almost everyone has seen a board lie with its weight resting upon its two ends, and that its own weight caused it to settle in the middle. Upon this principle, a piece of steel will settle when annealing, if not placed in a proper position. But if dipped into the water perpendicularly, the result will be, that when it is hardened, it will spring or strain itself to its proper position.

56. *Cutting the Spiral Grooves.*

This is done in a machine made for the purpose, which contains a spindle, which revolves slowly while the grooves are being cut. This spindle also slides slowly, while grooves are being cut, and contains a screw, upon the end of which is fastened a chuck, for holding the drill. You will put your drill into this chuck, and raise the sliding block which is beneath the drill, until it touches the drill, taking care not to raise it too high, so that the drill shall be raised above the centre of the chuck into which it is screwed. Having adjusted your machine, you will put in a cutter, and groove your drills as follows: for drills one eighth of an inch in diameter, cut them two to the inch, calculating as you would in cutting a screw to an engine lathe, and the depth of the groove should be cut to within one hundredth of an inch of the centre of the drills. For drills one half an inch in diameter, one and a half to the inch, and down to within a sixty-fourth of the centre. Drills one inch in diameter, should be cut one to the inch, and down to a thirty-second of the centre. The index plate will give you the two opposite points from which to commence cutting.

The thickness of the cutter should be one half the diameter of the drill, and the edge of the cutter or teeth should be rounded to a perfect circle.

57. *Flat Drills for Chucking.*

Such drills should be made of three lengths only. That is: when a lot is made for a shop, all sizes of three-fourths of an inch and above, should be made fifteen inches long. All sizes from three-fourths, down to three-eighths of an inch, ten inches, and sizes below that, five inches long. This saves the time usually lost in moving your puppet, when drilling your hole with several differently sized drills. As these drills are made to be followed by certain sized reamers, they should be made exactly one hundredth of an inch, at their ends, smaller than the reamer designed to follow them, and should be tapering, so as to measure, at a distance of three inches from the points, one hundredth of an inch smaller than at the point. Run this taper to the centre. Draw-file the edges, the same shape as turned by the lathe. Such drills should never have their edges filed square, as they are made in some country shops, for it is impossible to drill two holes of a size, with

drills made in this way. The more nearly square such drills are made on their ends, the longer they will wear. It is necessary, however, to take off the corners. In hardening such drills, it is not necessary to draw the temper, as they never break, and it is my philosophy never to draw the temper of a tool that is not liable to break, for the harder they are, the longer they will wear.

58 *Tap and Reamer Wrenches.*

Tap and reamer wrenches should be made square in the middle, and should have a square hole punched, or cut, through the square, to hold the head of the tap, or reamer, while the ends should be turned round, to within half an inch of the hole in the middle.

59. *Proportions for Tap and Reamer Wrenches.*

Very small taps should be used in file handles. Wrenches for taps, and reamers, from one-eighth of an inch to five-sixteenths, should be five inches long, with a square in the middle half an inch in diameter, and a square hole cut through it, three-sixteenths in diameter. The ends are to be turned rounding, half an inch at extreme ends, and five-sixteenths near

the hole in the middle. The extreme ends should be rounded with a hand tool and polished, so as not to hurt the hands of the user.

60. Tap and Reamer Wrenches, Size two.

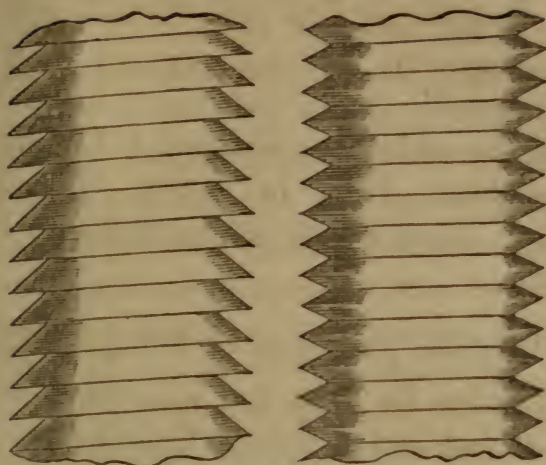
Wrenches for taps, and reamers, from five-sixteenths to seven-sixteenths, should be ten inches long, with a square in their middle five-eighths in diameter, and a square hole through square, five-sixteenths diameter. Ends round, five-eighths by seven-sixteenths.

61. Tap and Reamer Wrenches, Size three.

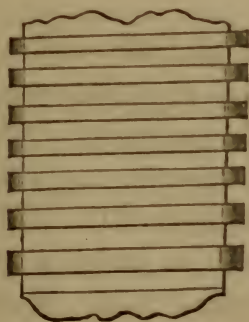
Wrenches for taps and reamers, from seven-sixteenths to five-eighths, should be fifteen inches long. Square in middle, seven-eighths. Hole through square, seven-sixteenths. Ends turned rounding, three-fourths by nine-sixteenths.

62. Wrenches for Taps and Reamers, Size four.

Wrenches for taps and reamers, from five-eighths to thirteen-sixteenths, should be twenty-four inches long. Square in middle, seven-eighths by one and one-eighth inches. Hole through largest way five-eighths. Square ends, turned seven-eighths by eleven-sixteenths.



17.—A V-Thread Screw. 18.—A Screw for great strength.



19.—A Square Thread Screw.

63. *Wrenches for Taps and Reamers, Size five.*

Wrenches for taps and reamers, from thirteen-sixteenths to one inch, thirty inches long. Square in middle, seven-eighths by one and three-eighths. Hole in square, thirteen-sixteenths. Ends, round, seven-eighths by three-fourths.

64. *Wrenches for Taps and Reamers, Size six.*

Wrenches for taps and reamers, from one inch to one and a fourth, forty inches long. Square in middle, one inch and five-eighths by one inch. Hole through square, one inch. Ends turned, one inch by seven-eighths.

65. *Making Taps. The Turning.*

This is a process requiring care, and every tap should have immediately under its head, or square for the wrench, a place turned exactly the size of the outside of the thread. You have then no trouble in getting the size of the threads, when they have an odd number of flutes in them. Every tap should also be exactly the size of the bottom of the thread, from the termination of the thread, which is usually about middling, to within about half an

inch of the head, or square. This you will leave, to get the size of the outside of the thread, as aforesaid. It is a foolish error in tool makers, to make a tap stiff above the termination of the thread, for the reason, that when in tapping a hole you come to a sudden stop, the tap is sure to break; when, if it were turned straight from the terminus of the thread, nearly up to the head, it would twist, instead of breaking.

66. *Proportions of Screws.*

The sizes marked below half an inch, in this schedule, are in proportion to the strength of the screw, and as they are mostly used with a screw-driver. I think them fully coarse-threaded enough for all purposes. The numbers marked coarser than seven to the inch, are calculated for square-thread screws.

Screws of one-sixteenth in diameter, fifty to the inch.

Screws of one-eighth in diameter, forty threads to the inch.

Screws of three-sixteenths in diameter, thirty to the inch.

Screws of one-fourth in diameter, twenty-five to the inch.

Screws of five-sixteenths in diameter, twenty to the inch.

Screws of three-eighths in diameter, seventeen to the inch.

Screws of seven-sixteenths in diameter, fourteen to the inch.

Screws of half an inch in diameter, twelve to the inch.

Screws nine-sixteenths in diameter, twelve to the inch.

Screws five-eighths in diameter, eleven to the inch.

Screws eleven-sixteenths in diameter, eleven to the inch.

Screws three-fourths in diameter, ten to the inch.

Screws thirteen-sixteenths in diameter, ten to the inch.

Screws seven-eighths in diameter, nine to the inch.

Screws fifteen-sixteenths in diameter, nine to the inch.

Screws one inch in diameter, eight to the inch.

Screws one inch and one-sixteenth diameter, eight to the inch.

Screws from one and one-eighth to one and one-fourth in diameter, seven to the inch.

Screws from one and one-eighth to one and one-fourth of an inch in diameter, seven to the inch.

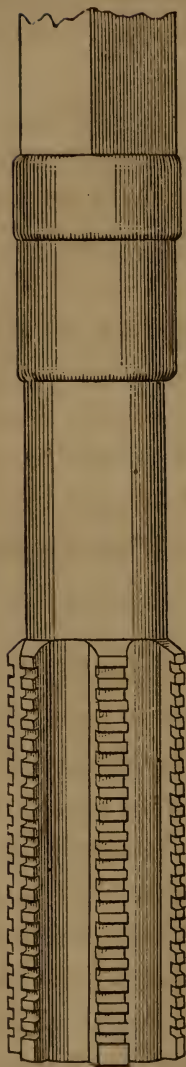
Screws from one and five to one and seven-sixteenths in diameter, six threads to the inch.

Screws from one and a half to one and eleven-sixteenths in diameter, five threads to the inch.

Screws from one and three-fourths to two inches in diameter, four threads to the inch.

67. *Cutting the Threads.*

V-thread taps should be cut with a tool exactly three-square. Some contend that they should be cut the depth of their pitch, but I consider three-square the best proportion, except where the thread is rounded on the top. They should be finished with a sharp tool, and the threads should never be polished *in* the threads, as the polish produces a glaze, on the iron, or steel, while tapping,—which would not be the case, were it left rough. In cutting a tap for ordinary machine screws, or bolts, you should measure with a pair of sharp callipers, the bottom of the thread of one of the screws, and cut your tap at the bottom of the thread, the same size. As the sizes of the screws



20.—Side view of a Square Thread-Tap.



21.—End view of a Tap or Reamer—properly Fluted.

are so irregular, this is the safest way to get a fit.

68. *Square Thread-screws.*

Taps for square thread-screws, designed for strength, should be cut one-half the depth of their pitch. Therefore, if your thread is five to the inch, you will cut it one-tenth of an inch deep. Your threads being five to the inch, there would be a space between the threads one-tenth of an inch, and the thread being one-tenth wide, and one-tenth deep, would form the square thread. Square threads for wear, however, should be cut three-fourths the depth of their pitch.

69. *Mongrel, or half V, half square Threads.*

These threads, made for great wear, are difficult to cut. They should be cut the depth of their pitch, and for extra great wear, where a screw is required to be kept accurate for a long time—such as the lead screw for a lathe,—they should be cut one and a half the depth of their pitch. The outside of the thread, also the bottom of the thread, should be in width, one-fourth of the thread's pitch. Therefore, if you were cutting a screw, five to the inch, it should

be one-twentieth in width on the outside, and one-twentieth at the bottom of the thread.

70. *Fluting Taps.*

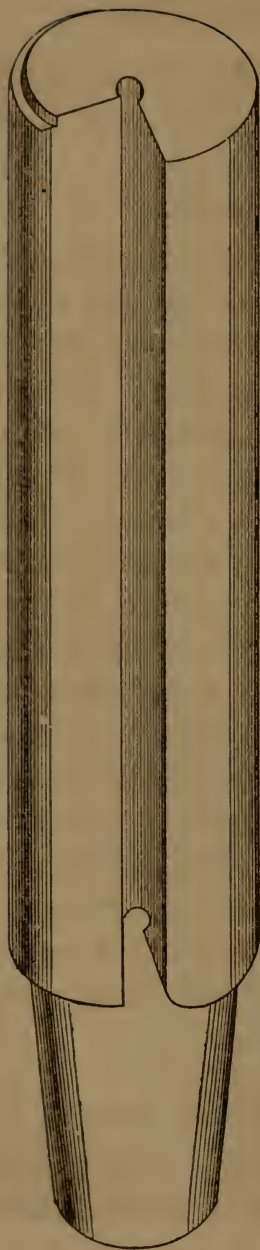
Every tap should be fluted with the teeth a little hooking on the face. That is, in striking a line through the middle of the tap, on the end, the flute or groove should be inside that line, while the flute at the outside of the thread is exactly *on* the line. The back side of the teeth, however, may lean a little outside of the centre, but not enough to allow the dust to ride over, when backing out the tap. It is needless to say that it is impossible, in steel, to cut a coarse thread full with a tap, that has the faces of its teeth leaning backwards, without tearing out half the threads, for taps, made with the faces leaning backwards, do not cut, they merely stretch and tear the thread to its size, instead of cutting it. It is, in fact, upon the principle of turning a shaft with a square end tool, with the point or end leaning downwards.

71. *How to go to work.*

Set your tap on the centres, and with a cutter or planing tools made round at the end, and the thickness of the end one-fourth the diame-

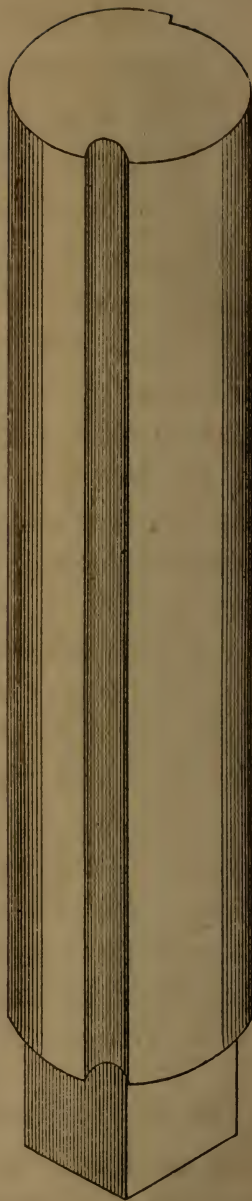
ter of the tap. Plane the faces of all the teeth, one-half the depth of the thread below the bottom of the thread. For instance, if a thread is an eighth of an inch deep, plane or mill it one-sixteenth below the bottom of the thread. After planing all the faces, or milling them all to their depth, plane or mill off the back sides of the teeth, leaving them one and a half the breadth of their pitch. Thus, if the pitch is ten, leave them a tenth, and a twentieth. This leaves fully stock enough for strength, and the less bearing a tap has, the more easily it turns. The back sides of the teeth should be finished with a cutter, or planing tool, made in thickness of the size of the tap. It is economical to have two taps for every thread, and have the first one small enough to cut only two-thirds of the thread, and the second to finish. Taps, for five threads, made in this way, need no taper. They never go hard, and do not get broken, half so often, as when they are both of a size. Very large mongrel thread taps should always be of two sizes, at least, for the threads being so coarse, and there being so much metal to cut out, it would be almost impossible to cut the thread otherwise, without tearing them. For hardening and tempering taps,

22.—A Drill with Single Lip, for drilling holes very straight.



22.

23.—A Reamer with Single Lip, usually made half round.



23.

see articles on "Hardening and tempering tools."

72. *Fluted Reamers.*

Fluted reamers should first be turned to within a thirty-second of an inch of the required size, and then heated and allowed to cool in an upright position, before finishing. This takes out the strains, and the hardness made in places by hammering out, so that they will not spring when heated for hardening. In fluting reamers, merely fluting them with an odd number in view of preventing them from chattering, is not sufficient. For when a reamer chatters, it jumps from lip to lip; hence it is necessary to make the lips uneven. Flutes in reamers from one-fourth to five-eighths of an inch in diameter, should be five. The number in reamers from five-eighths to one inch, should be seven. The number in reamers from one inch to one and a fourth, should be nine. The number from one and a fourth to one and a half inches should be eleven.

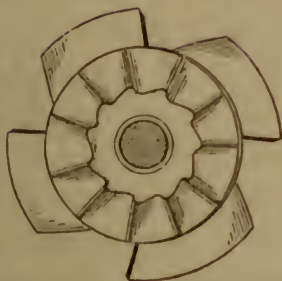
73. *How to make a Fluted Reamer.*

Have the head forged to fit a certain wrench. Then make good centres in it, for these are ne-

cessary to keep it true. Turn it to within a thirty-second of the required size, then heat it and let it cool in an upright position. Then, turn the part designed for the lips, one-hundredth of an inch larger than the size at which you intend to finish it, then turn a place in the middle of it five-eighths long, and one-twelfth of the reamer's size, smaller than it is. This is the place to pene it straight, after hardening. After turning all but the upper part (which is to be turned after it is hardened and straightened), you commence fluting it, by putting it on the centres, and if you flute it on a planer, use a round-end tool, one-tenth of an inch in thickness, and plane it down to the face of every lip, down to the bottom of the place made for pening, and plane them so that in every other two of the lips, the space between them will be shorter than that of the two preceding them. After doing this, use a square end tool, and plane off the back side of the lips, up to within a thirty-second of an inch of the face. The faces of these lips should be planed straight with the centre. File the lips smooth, then harden it. For hardening it again, see articles on "Hardening and tempering tools." Then pene it straight. Then, turn the upper part to

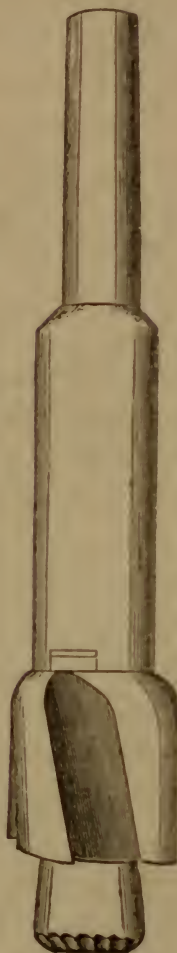
24.

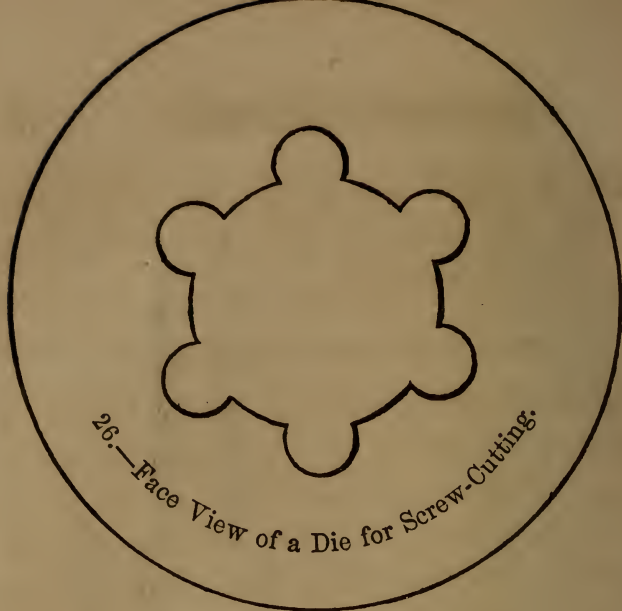
24.—End View of a Counter Boring-Tool.



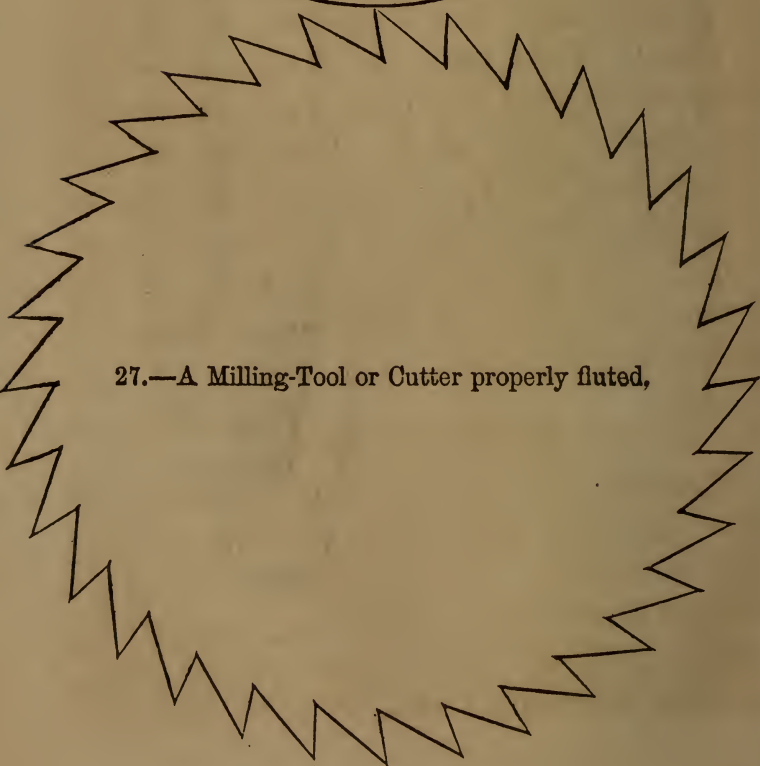
25.

25.—Side View of a Counter Boring-Tool.





26.—Face View of a Die for Screw-Cutting.



27.—A Milling-Tool or Cutter properly fluted,

the size required and polish it. And then grind the lips down to size, and have them sharp, and it is finished.

74. *Half-round Reamers.*

Half-round reamers should never be made, in this age, but should be superseded by a single lipped reamer, made in the following style. Get a piece of steel, and have the head forged, for a certain wrench, and as single-lipped reamers usually taper, turn it tapering, and perfectly round. Then put it on centres, and with a small round point tool, plane a groove through the whole length of it. One side of this groove forms the lip. Then from this groove plane off a sixty-fourth of an inch, half way round. File up the face of the lips, on a line through the centre, on the end. Harden and temper, and it is done.

75. *Rose Reamers.*

These reamers are only used for boring out holes that have been cored, and cannot otherwise be drilled. They sometimes have a hole through them, and are, where large ones are required, generally fitted upon an iron shaft, which is afterwards turned off to the same size

as the reamer. Their ends should be square, with the corners taken off. Their lips should be cut about nine to the inch, on the end, and a little hooking. Harden the same as other reamers.

76. *Counter-boring Tools.*

To make a counter-boring tool, first fit the shank to a certain collet, then turn the governor, which should not be more than a quarter of an inch long, and after this, turn a place for the lips, about three-eighths of an inch long, on small ones, and about three-fourths on large ones. Beyond this place, turn it about one-third larger than the governor, and straight, up to the shank, by leaving the place for the lips short, and thus, it saves filing. You will then file four lips in them spiralling, like a drill, then file off the back side of the lips on the end, up to an edge, harden, and it is done. Flat counter-boring tools are only made by ignoramuses, who break as fast as they make them.

77. *Making Dies for Screw-cutting.*

In making dies for screw-cutting, they should, wherever practicable, be lapped with a taper tap, as they cut more easily and wear

longer, than those which are cut straight, and then tapered off, to make the screw "take."

Very fine threaded screws, however, cut well with straight dies. Small dies, or dies below one-fourth of an inch in size, should only have three lips in them. Dies from one-fourth to one-half should have four lips in them. Dies from three-fourths to one inch should have six lips in them; and dies from an inch to an inch and a half should have seven lips in them. The cuts through dies should be only twice the depth of the thread,—which is sufficient to make them free themselves from chips—for when cut too deep they are liable to break out on the face. Harden, and draw to a straw color.

78. *Milling Tools.*

Thin milling tools or cutters should be chucked to fit loosely on the arbor of the machine, in order that they may not be too small after hardening. They should then be turned to within a thirty-second of the required thickness, and then, be again heated before finishing. The heating a second time takes out the strains and hard places, so that they are less liable to spring when heated for hardening.

79. *Proportionate numbers of Teeth, in different sizes.*

The number of teeth to the inch in different cutters, should vary in proportion to their sizes. Very thin cutters of all sizes should be cut very fine, as they are very easily broken when the teeth are coarse. The following list will probably give as good proportions as can be well arrived at. At least I have spent considerable time in "figuring them out," and can find none that I think better.

Cutters one-tenth of an inch thick, should have thirty teeth to the inch for large sizes, and thirty-five for small sizes.

Cutters from one-eighth to three-sixteenths in thickness, should have twenty-five to the inch for large sizes, and thirty for small sizes.

80. *Proportions of Broad Cutters.*

Cutters half an inch in diameter, should be cut thirty to the inch; and contain eighteen teeth, of one-sixteenth of an inch deep.

Cutters three-fourths of an inch in diameter, should be cut thirty-two to the inch and contain twenty-four teeth of one-fifteenth of an inch deep.

Cutters one inch in diameter, should be cut twenty-eight to the inch, and contain twenty-eight teeth, of one-fourteenth of an inch deep.

Cutters one and a half inches in diameter, should be cut twenty-four teeth to the inch, and contain thirty side teeth, one-twelfth of an inch deep.

Cutters two inches in diameter, should be cut twenty teeth to the inch, and contain forty teeth, cut one-tenth of an inch deep.

Cutters three inches in diameter, should be sixteen to the inch, and contain forty-eight teeth, cut one-eighth of an inch deep.

Cutters four inches in diameter, should be thirteen to the inch, and contain fifty-two teeth, cut one-sixth of an inch deep.

Cutters five inches in diameter, should be cut, eleven to the inch, and contain fifty-five teeth, cut one-fifth of an inch deep.

Cutters six inches in diameter, should be cut ten to the inch, and contain sixty teeth, cut one-fourth of an inch deep. The teeth of these cutters should always be cut hooking, and the large sizes should be left nearly a sixteenth of an inch thick at the edge. The outer surface of the cutter should be draw-filed nearly square with the faces, as they cut more

smoothly than when filed too sharp. Harden, and draw to a straw color.

81. *Punches and Dies.*

In making these, it is necessary to fit the piece intended for the die into the slide or plate of the punch, and you may then put it in its place, and run the slide which holds the punch, down upon it. This slide is nearly round, and you may, after running it down, mark around it upon the piece intended for the dies, and cut your die, so the centre of it will come in the centre of the place marked on it. The die should be cut through square with its face. Such dies should be made higher in the centres, or where the hole is cut through, than its general surface, in order that they may be ground off when dull. After finishing the die, harden it, and put it into its place. Then fit the shank of the piece intended for the punch into the slide, then put the punch into the slide, and run it down upon the die. Then mark through the die, on the end of the punch, its desired shape. Then take out the punch and cut it down very nearly to the mark, and you may then put the punch into the machine again, and press it into the

die an eighth of an inch, and this will give its shape perfectly. Harden, and it is finished.

82. *Making Gauges.*

In the making of gauges, or forms for cutting or drilling machinery, it would be impossible to give any correct details, as the styles and shapes are too numerous, and I can only say, that it is necessary to leave them enough larger before hardening, to allow for what they will contract, or spring, when hardening. After hardening, they should be ground, on machinery made for the purpose, to the required size. Gauges for drilling may be made at their proper size before hardening, as they cannot be ground *after* hardening.

83. *Note on Balance-wheels.*

Although balance-wheels have been used for several centuries, the mode of applying them seemed never to have been known. I therefore endeavored to ascertain this, and have discovered that every balance-wheel should be speeded up, so as to run twice or three times as fast as the crank-shaft it is intended to balance; and that where a balance-wheel is applied in this way, it makes the machine run a great

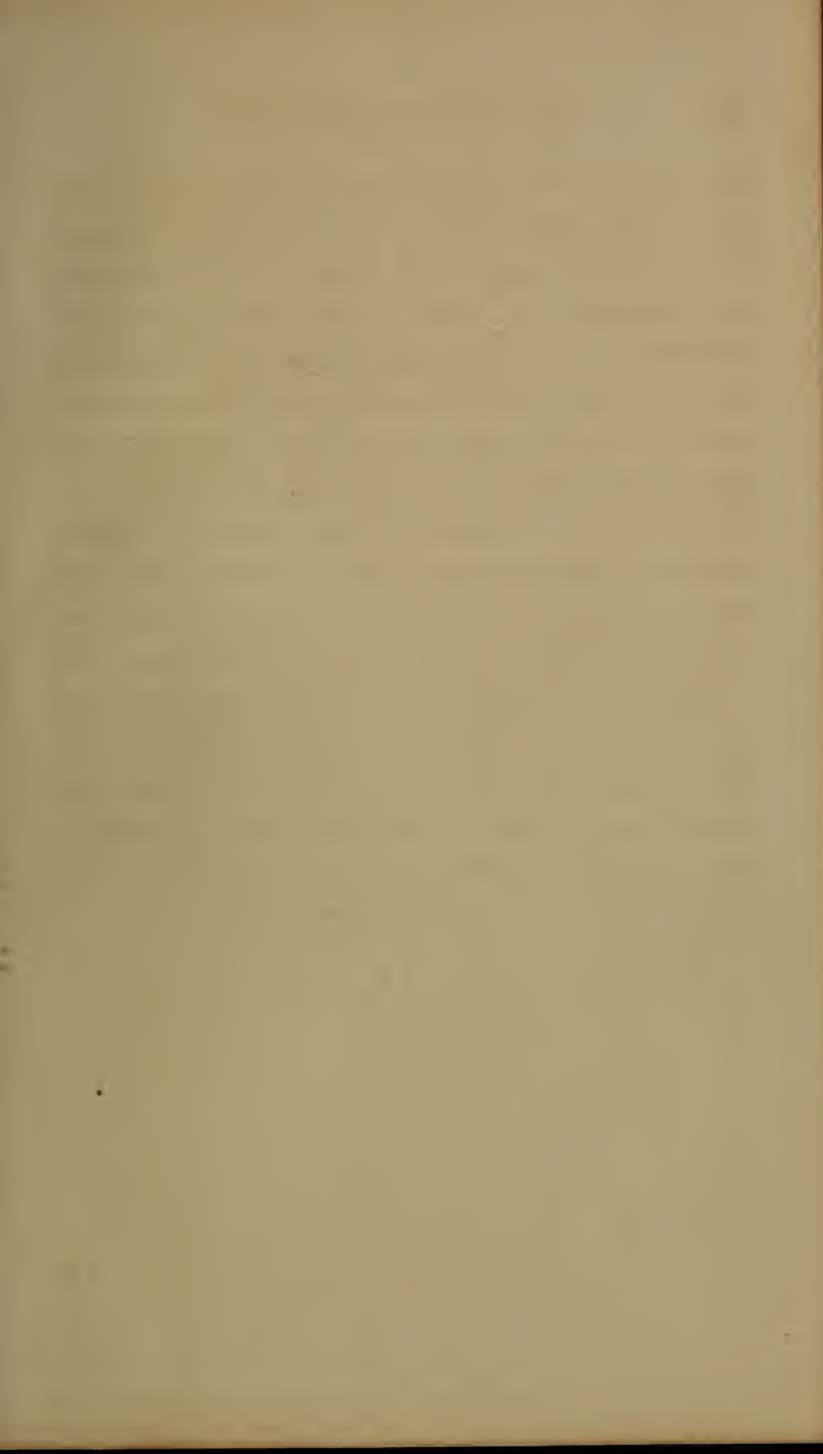
deal more steadily, for when the balance-wheel is geared into the crank-shaft, and runs two or three times faster than the crank-shaft, it forms a power of itself, when going over the centre, which propels the crank-shaft until it reaches the quarter where it again takes its power from the machine. Although it takes an additional shaft and geers to apply a balance-wheel in this way, the saving of metal in the balance-wheel fully compensates for the extra labor, for when a balance-wheel is speeded three times as fast as the crank-shaft, it needs only one-third of the metal in it that it would, were it not speeded up at all, and if balance-wheels were applied in this way generally, it would make all engines run far more steadily.

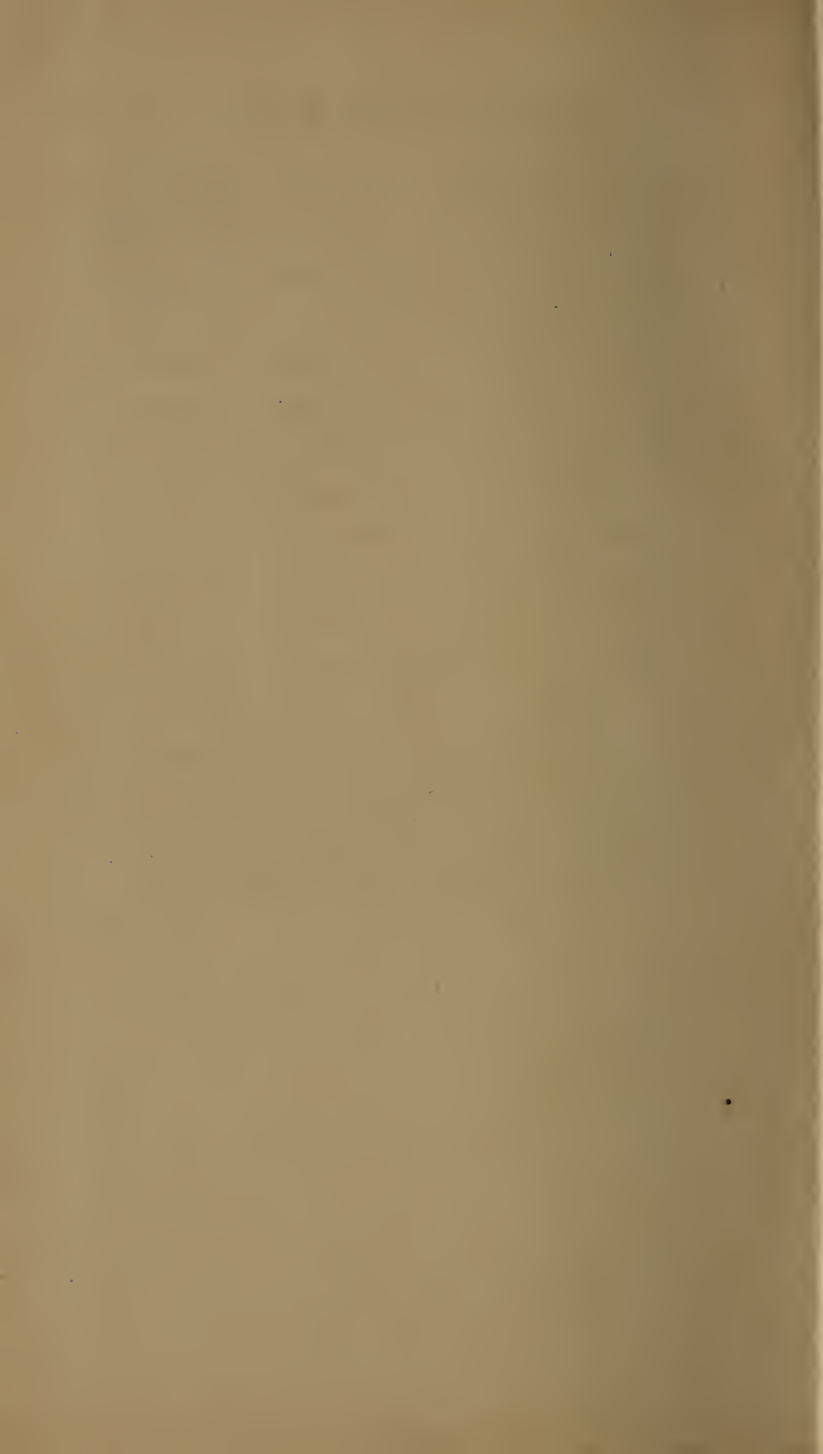
84. *A few words as to Master Mechanics.*

It may safely be said that not one master mechanic in twenty knows his business thoroughly. Nineteen of that twenty will only buy such heavy tools as he is forced to have in order to do his business, and then, for the want of a few small tools, that would cost comparatively nothing, some cotton waste with which to keep them clean, and a little care to see that it is done, his shop will be encumbered

with rubbish and filth, his lathes, planers, milling machine, etc., etc., covered with grease, so as to be unfit for use, and his men spend one-third of their time, looking for a bolt, strap of iron, or some other petty thing, of less worth than the time spent in looking after them. These are the shops that generally go to ruin. And all this, for the want of a superintendent who has common sense, and is not asleep on duty. These remarks, however, do not apply to shops where guns are manufactured, as it is well known that they are kept in order. The mechanic who knows his business thoroughly, will have every tool kept clean, and in its place. He will have a sufficient number of taps, lathes, reamers, drill and planer tools, with all other small tools, so that no man need wait a moment for want of them; for "time is money." He will keep his dogs, geers, cutters, and drills, as near the machines they are used upon as possible, and thereby save trouble, and be more likely to ensure them in their places. He should have for every planer, half a dozen straps, made of one inch by half an inch iron, and bent in a U shape, near enough together to hold a three-fourths inch bolt. These straps need no drilling for the bolt, and

are far more "handy" than straps with holes drilled through them. He should have three-fourths inch bolts, of a dozen sizes, with nuts an inch thick, in order to prevent stupid workmen from stripping them. He should see that the centres of arbors, when made, are counter-sunk, perfectly three-square, and that the centres of the lathes likewise are kept perfectly three-square. Unless he does this, the arbors will spoil the centres of the lathes, and the centres of the arbors will soon wear out of true, and the arbors thus be rendered worthless. He should have plenty of drills, so they need not be altered every time he has a new hole to drill. He should have holes for drills in all small collets, of such a size, that one drill can be used in any part of the shop; and the large ones likewise.



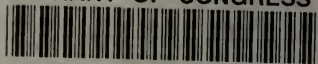








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